

Appl. No : 09/993,069
Amdt. dated August 21, 2003
Reply to Office Action of 07/21/03

Amendments to the Specification

- 1) page 1, last paragraph, page 2, first paragraph, please replace this text with the following amended paragraph:

A photolithographic mask is one of the essential components that is used for creating patterns of exposure on semiconductor surfaces. The photolithographic mask contains a pattern of device features that must be transposed from the mask to underlying layers of semiconductor material such as for instance a layer of photoresist.

A standard photo mask contains a transparent substrate, typically made of quartz. A patterned layer of opaque material has been created over a surface of the transparent substrate. Chromium is typically used for the opaque material, deposited to a thickness of about 1,000 Angstrom. Alternate opaque materials for the creation of the patterned layer on the surface of a photolithographic mask are nickel and aluminum.

More sophisticated photo masks apply the principle of phase shifting of the light as the light passes through the mask.

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Phase shifting masks are used to create device features of sub-micron dimensions.

It is well known in the art that adjacent light beams, which are in extreme close proximity to each other while the light beams are used to create sub-micron devices device features, mutually influence each other, having a detrimental effect on the formation of the exposed patter pattern. The phase shift mask counteracts this mutual influence that closely spaced light beams have on each other.

2) page 3, second paragraph, please replace this text with the following amended paragraph:

The photolithographic mask is created using conventional methods (including sputtering) of depositing a layer of opaque material over ~~a surface of~~ the substrate of the mask and patterning this layer using conventional high resolution methods of exposure such as E-beam exposure.

Due to the frequently used high density of the pattern that is developed in the layer of opaque material, this formation is exposed to a number of problems that result in bad and unusable masks.

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These masks are frequently repaired, based on a cost analysis as to whether it is best (most cost effective) to repair the mask or whether it is best to scrap the defective mask.

Some of the defects that can occur in the creation of [[a]] an opaque pattern over the surface of the substrate are opaque material remaining in place where it should be removed and visa versa, the formation of an interconnect or bridge between closely spaced adjacent lines of the opaque pattern, extensions of the opaque material into transparent surface regions of the mask, the occurrence of an isolated opaque spot in a transparent region ~~and visa versa~~, the formation of pin holes in either the opaque or the transparent surface area, and the like.

3) page 4, last paragraph, page 5, first paragraph, please replace this text with the following amended paragraph:

A principle objective of the invention is to provide a method of repairing Phase Shift Masks (PSM) whereby the function of repair has no detrimental effect on the transmission rate and the phase angle of the PSM.

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4) page 12, last paragraph, page 13, first paragraph, please replace this text with the following amended paragraph:

Where [[Figs.]] Fig. 1a shows an excess of light shifting material, the cross section of Fig. 1b shows a deficiency 18 of light shifting material, which also can be caused by any irregularity or interruption in the process of forming patterned layer 12 of phase shifting material. The deficiency 18 of phase shifter material is eliminated by a deposition 20 of a hydrocarbon based gas, filling and overlying the deficiency 18 with a deposit of the gas 20, which is then radiated by the Focused Ion Beam (FIB) exposure 16 to partially evaporate the hydrocarbon base film and to solidify part of this film inside deficiency 18.

5) page 13, second paragraph, please replace this text with the following amended paragraph:

It will be appreciated and specifically relating to phase shifter masks, that light that passes through black bump 14 of Fig. 1a undergoes a 180-degree shift in phase.

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Since this light inversion takes place only for the light that passes through the black bump 14, this results in an interruption of phase shifting characteristics of the light that is projected ~~though~~ through the PSM. ~~whereby the~~ The light that passes through black bump 14 essentially fails to expose the underlying layer (of for instance photoresist). The developed photoresist will therefore not be removed in accordance with the desired pattern, raising obvious concerns of product performance and the like.

6) page 15, last paragraph, page 16, first paragraph, please replace this text with the following amended paragraph:

Optionally, the surface of layer 26 of photoresist can [[it]] at this time, represented by the cross section shown in Fig. 3, be baked in order to provide improved protection for the underlying elements 22 of phase shift material. This step of baking the layer 26 of photoresist can be performed using a temperature in the range between 300 and 700 degrees C[[.]], under atmospheric pressure, for a time between about 10 and 30 seconds.

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7) page 17, last paragraph, page 18, first paragraph, please replace this text with the following amended paragraph:

The completion of the repair action is shown in cross section in Fig. 7 with the removal of the excess width of layer 24, shown in the cross section of Fig. 6, from the surface of substrate 10. At this time the affect effect of the Ga implants into the surface of substrate 10 must be removed, which is achieved by applying an oxygen plasma etch 30 to substrate 10, shown in the cross section of Fig. 8, by heating substrate 10 in a highly oxidized environment. Substrate 10 is baked at a temperature of about 400 degrees C[[.]] with a range of about 350 to 450 degrees C[[.]], under a pressure of about 450 Torr with a range between about 400 and 500 Torr, with O₃ plasma flow of about 5,000 sccm/min[[.]] with a range of about 4,000 to 6,000 sccm/min.

8) page 18, third paragraph, please replace this text with the following amended paragraph:

As a final step, the invention removes the developed layer 26 of photoresist from the surface of the pattern 22 of opaque

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material by applying a wet strip, creating a repaired PSM 15,
which is shown in the cross section of Fig. 9.

9) page 19, last paragraph, please replace this text with the following amended paragraph:

It is clear that the method of the invention for repairing PSM mask 15, as described using [[Fig.]] Figs. 2 through 9, comprises:

- the pattern 22 of opaque shifter elements having been protected by a layer of photoresist during the repair operation, avoiding problems of impacting the transmission characteristics of the shifter and impacting the phase angle characteristics of the PSM, and
- the Ga stain has been removed from the surface of the substrate 10.

10) page 19, last paragraph, please replace this text with the following amended paragraph:

As a further advance, alternate phase shifting masks can be used, where the phase shifting characteristic of the phase

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shifting mask is alternately counteracted affected in the light
as the light passes through the photo mask.